Evidence of the California Undercurent in CTD Data Collected on the OC3570 Cruise February 2003

LT Mike Cornelius
OC#3570

The California Undercurrent

The California Undercurrent is a poleward flowing component of the California Current. In the summer months, the undercurrent flows almost directly beneath the upper level California Current along the base of the continental slope. In the winter months, the undercurrent manifests itself as the Davidson Current that flow more along the continental shelf. While the California Current brings colder, fresher water toward the equator, the California Undercurrent brings warmer, more saline water poleward at a depth that ranges from 100 meters to approximately 300 meters.

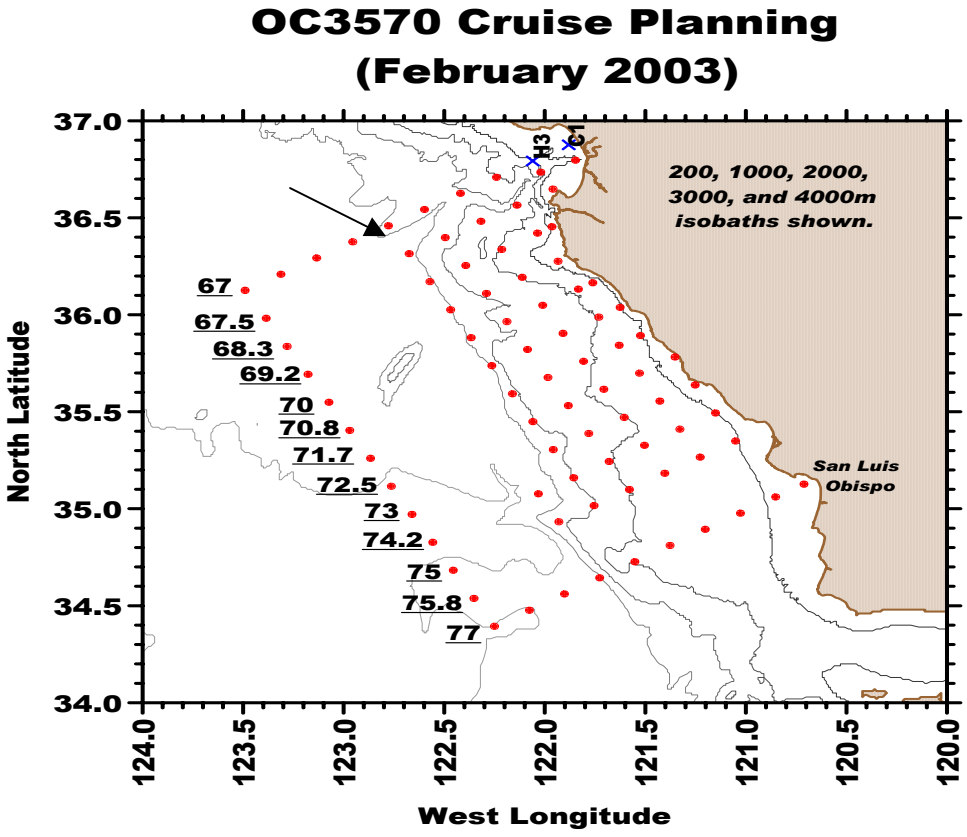
In order to detect evidence of the California Undercurrent in the data collected by the R/V Point Sur, CTD soundings were taken along the box denoted in the figures that follow. If evidence of the California Undercurrent existed, a jump in temperature, salinity and sound speed would be seen at approximately 100-300 meters.

Data Analysis

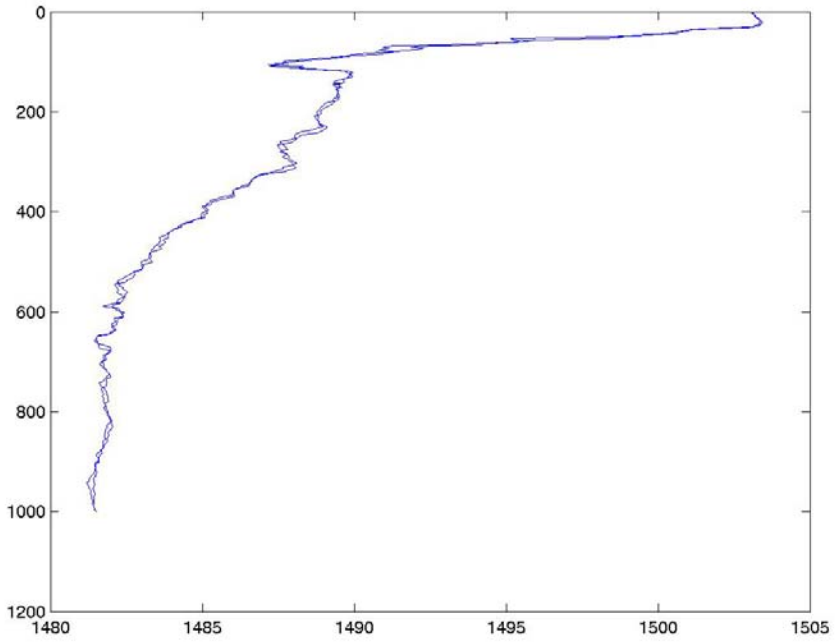
The CTD data was analyzed from each station and plots of sound speed vs. depth and temperature vs. salinity were created. Analysis is as follows:

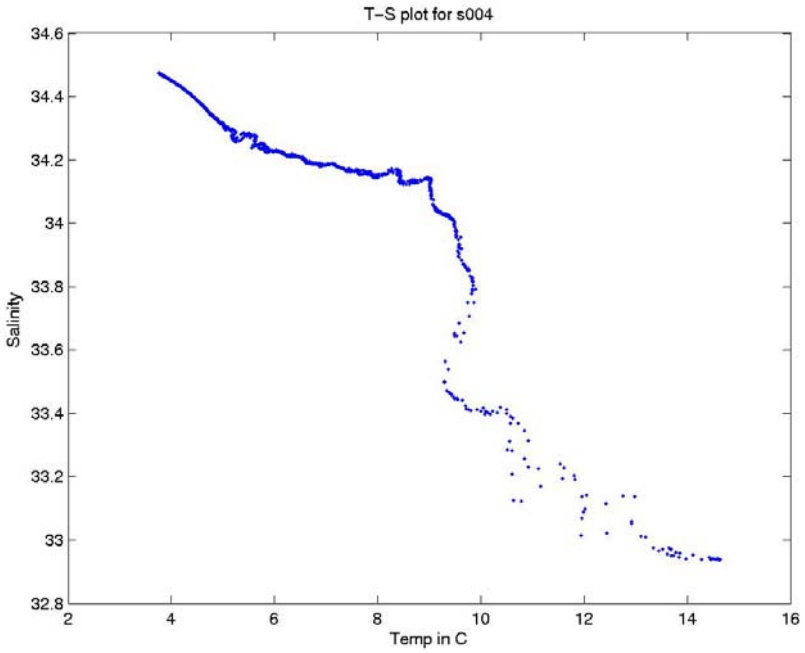
STATION S004

In the sound speed vs. depth (henceforth called C-Z) plot, a small anomaly is noted at 175 meters. A typical C-Z profile is characterized by an increase in sound speed from the surface down to several meters. This is caused by the increase in pressure with depth. In the surface layer, temperature is relatively constant due to mixing. At the base of this layer temperature begins to drop rapidly. As depth increases, the increase in pressure is not enough to overcome the drop in temperature and sound speed begins to decrease. Any change in this profile must have some cause. In this instance, the jump in sound speed is due to the influence of the California Undercurrent. In the temperature vs. salinity plot (henceforth called T-S), there is an influx of warmer, more saline water that further explains the jump in sound speed. Tactically this could lead to the formation of a subsurface sound channel that could be exploited. Sound channels focus sound energy allowing the energy to propagate much further than it could otherwise. The channel prevents rays from encountering the surface or the bottom. The surface is much less of a problem than the bottom.



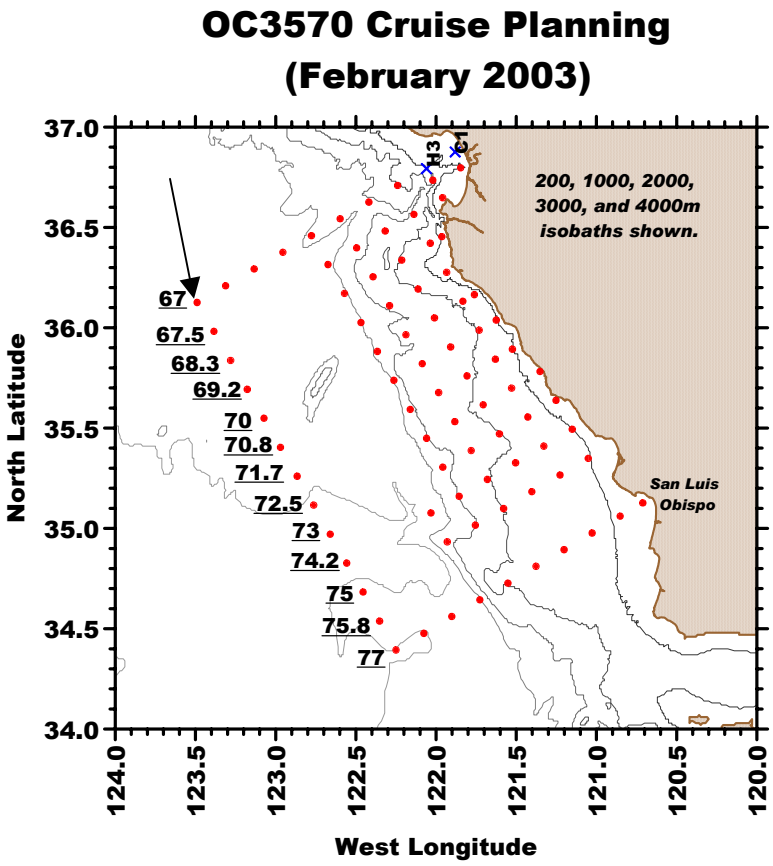
C-Z profile for station s004
(y-axis depth in meters, x-axis sound speed in m/s)

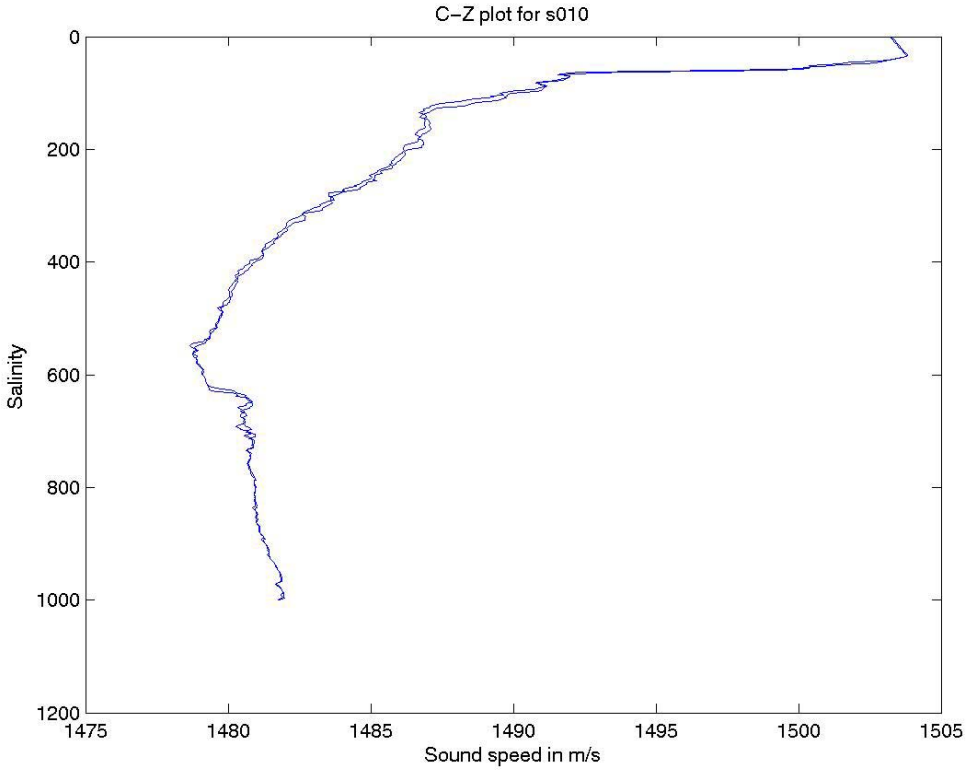


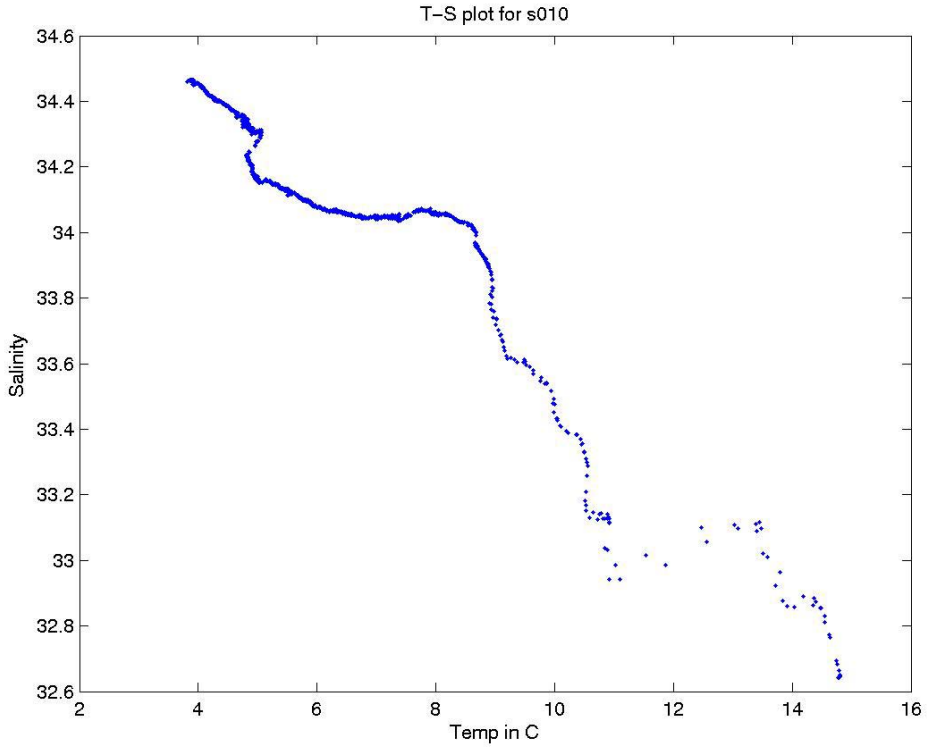


STATION S010

Station s010 is further out to sea than s004. An anomaly in sound speed exists at 175 meters, which is consistent with the signature of the California Undercurrent. However, the signature is far less than was evident at station s004. As was mentioned earlier, in the winter months, the Davidson Current dominates the poleward flow in this region. This would cause the signature of the warmer more saline water to be stronger near the continental shelf. This data supports that situation.

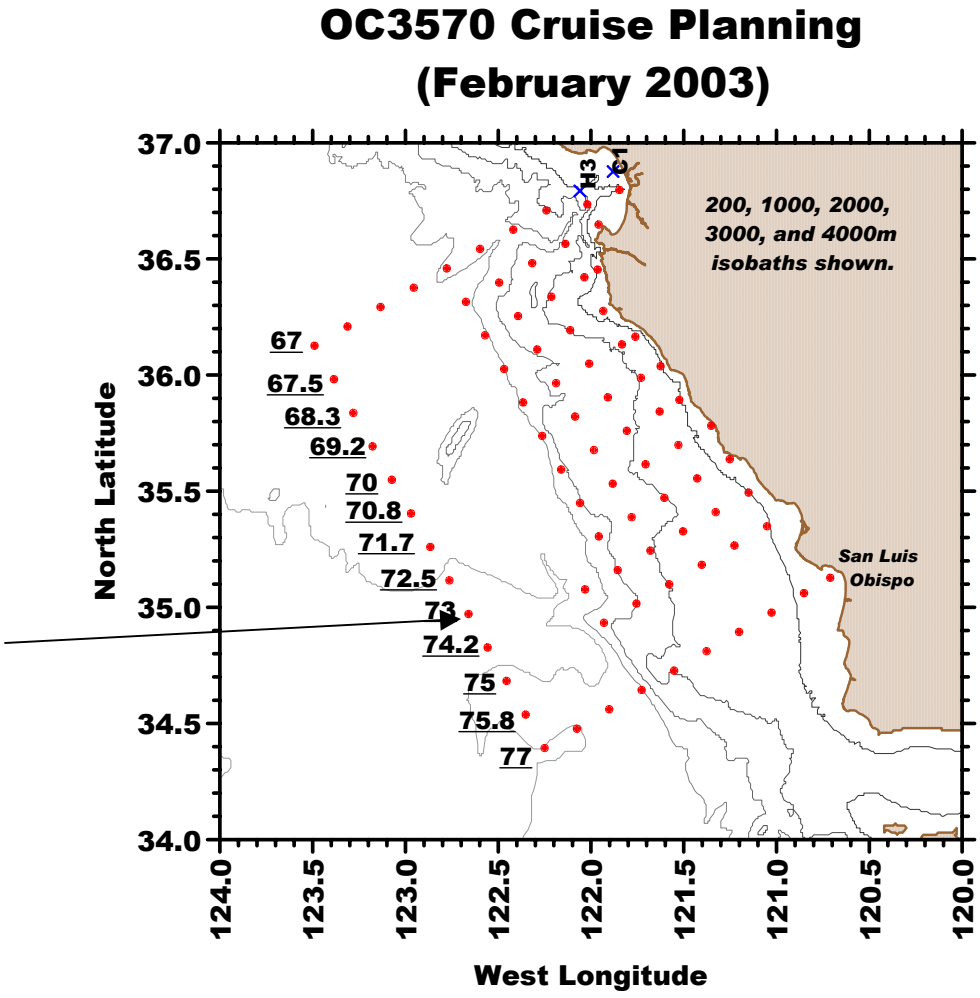

OC3570 Cruise Planning
(February 2003)
37.0
36.5
36.0
35.5
35.0
34.5
34.0
North Latitude
124.0
123.5
123.0
122.5
122.0
121.5
121.0
120.5
120.0
West Longitude
H3
C1
200, 1000, 2000,
3000, and 4000m
isobaths shown.
San Luis
Obispo
67
67.5
68.3
69.2
70
70.8
71.7
72.5
73
74.2
75
75.8
77


C–Z plot for s010
Salinity
Sound speed in m/s
0
200
400
600
800
1000
1200
1475
1480
1485
1490
1495
1500
1505

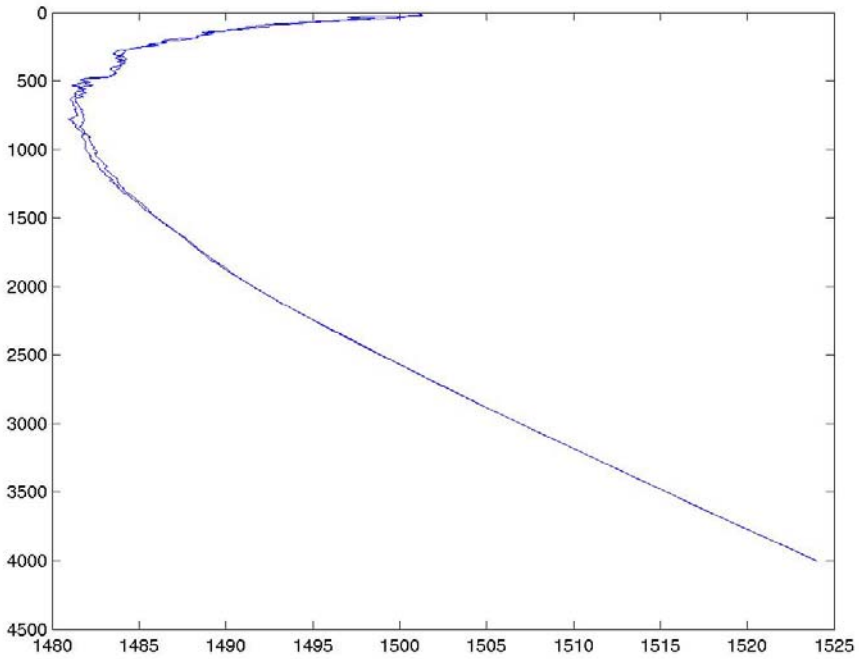

T–S plot for s010
Salinity
Temp in C
34.6
34.4
34.2
34
33.8
33.6
33.4
33.2
33
32.8
32.6
2
4
6
8
10
12
14
16

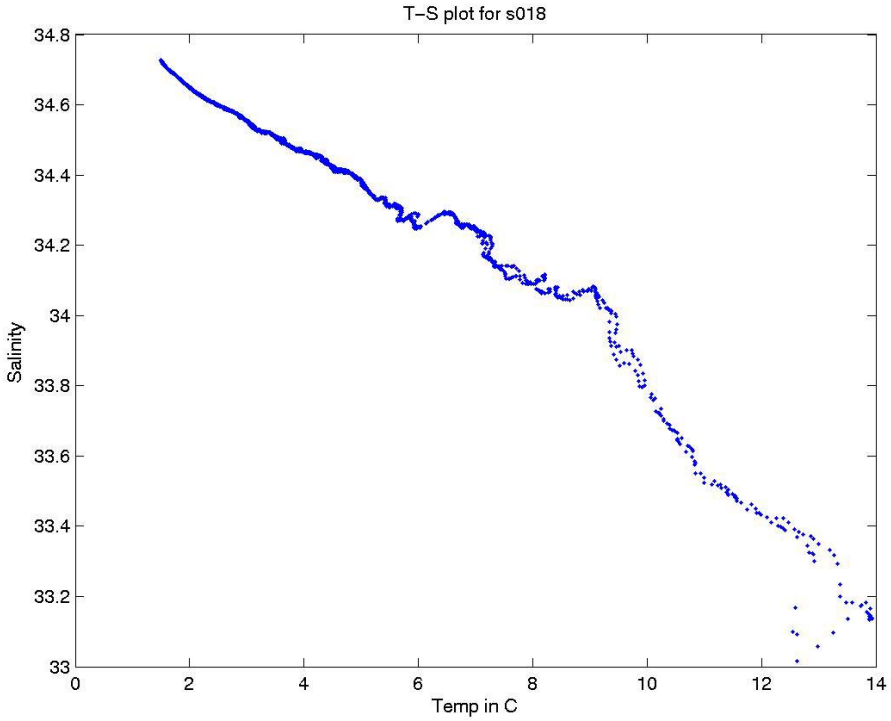
STATION S018

The deepest sounding taken on the OC3570 cruise of February 2003 was station s018. The depth at this location is over 4000 meters. A jump in sound speed exists at 300 meters. The rest of the sounding shows a very large deep sound channel that has significant depth excess. Both of these acoustic features could be easily exploitable in a tactical environment.



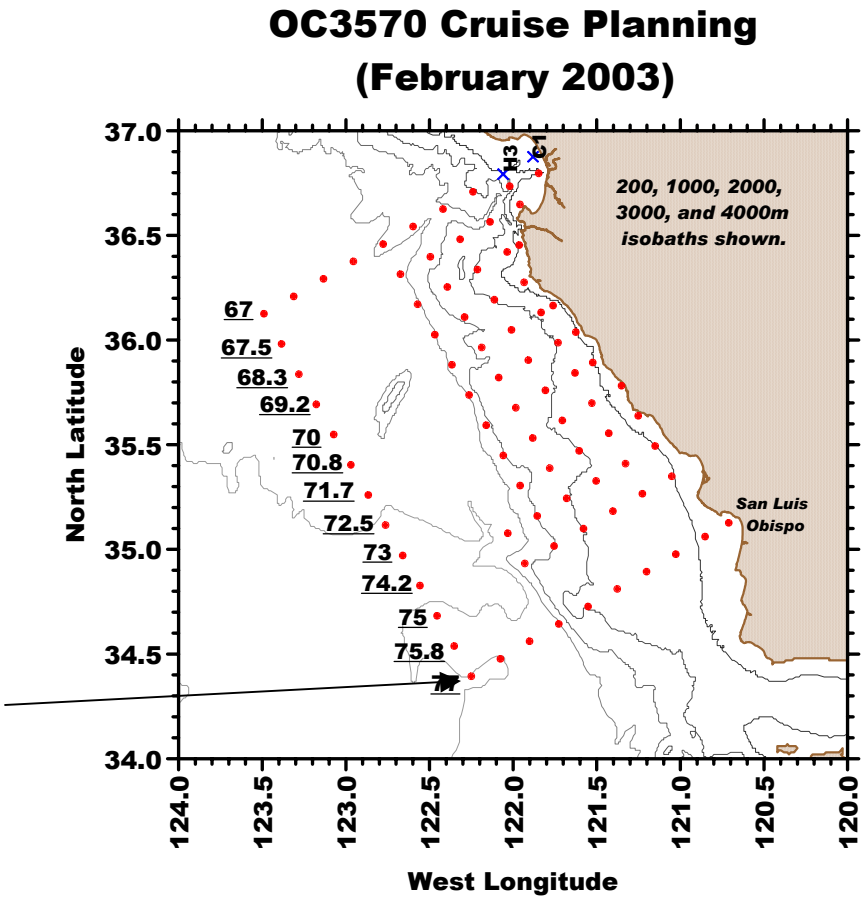
C-Z profile for station s004
(y-axis depth in meters, x-axis sound speed in m/s)

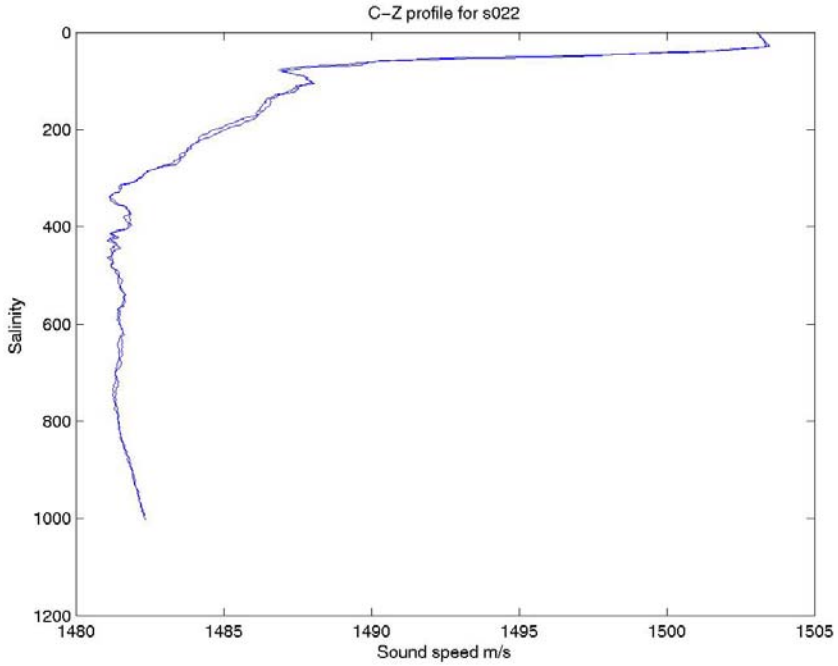


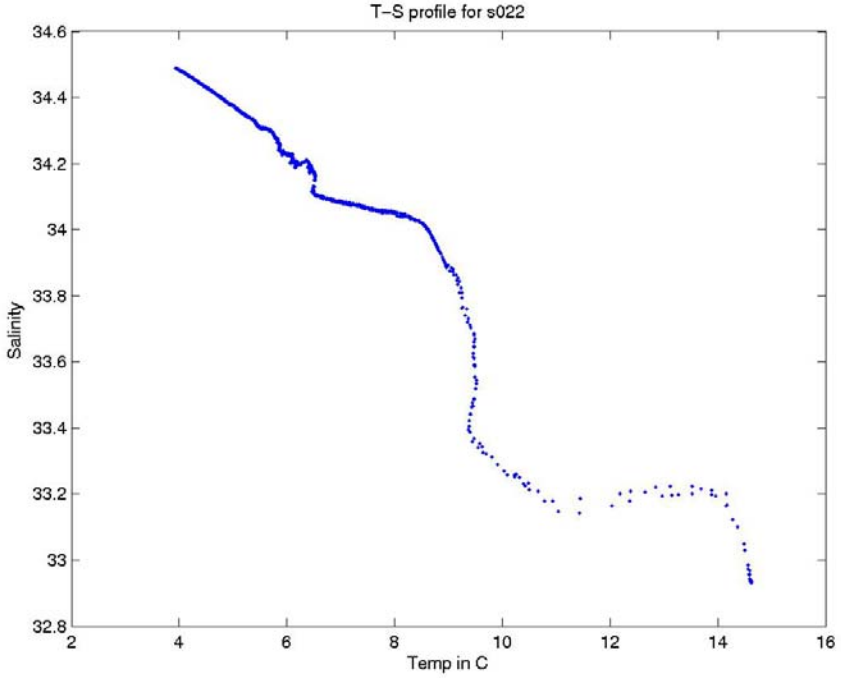


STATION S022

Station s022 was in the southernmost portion of the box. It had adequate depth for a deep sound channel to form and was in the region where the temperature and salinity markers of the California Undercurrent could be quite substantial. The C-Z profile shows a slight jump in sound speed at a depth of 100 meters, but the most interesting portion of this station is the T-S plot. The T-S plot shows a significant influx of warm, saline water. The California Undercurrent has a maximum speed and intensity near the Santa Barbara area. This supports the finding, that our southernmost point experienced the highest degree of influence.

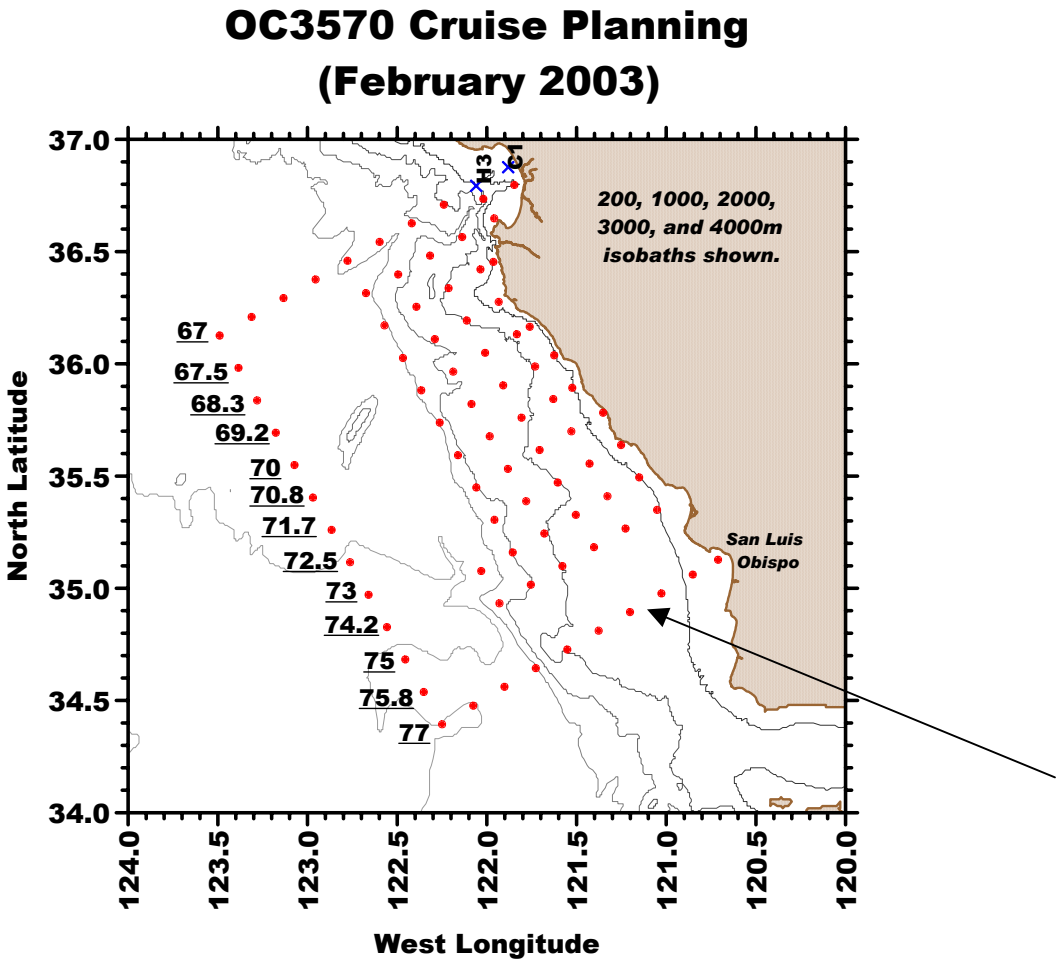



C–Z profile for s022
Salinity
Sound speed m/s
0
200
400
600
800
1000
1200
1480
1485
1490
1495
1500
1505

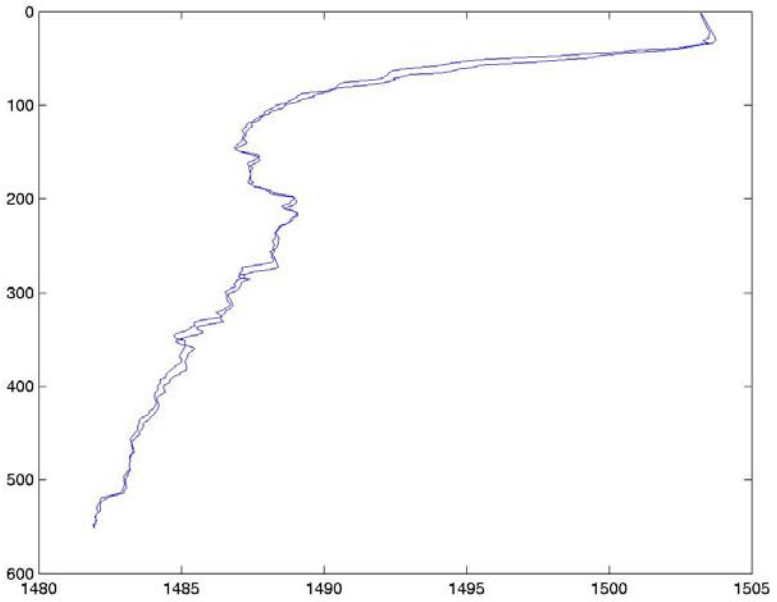

T–S profile for s022
Salinity
Temp in C
34.6
34.4
34.2
34
33.8
33.6
33.4
33.2
33
32.8
2
4
6
8
10
12
14
16

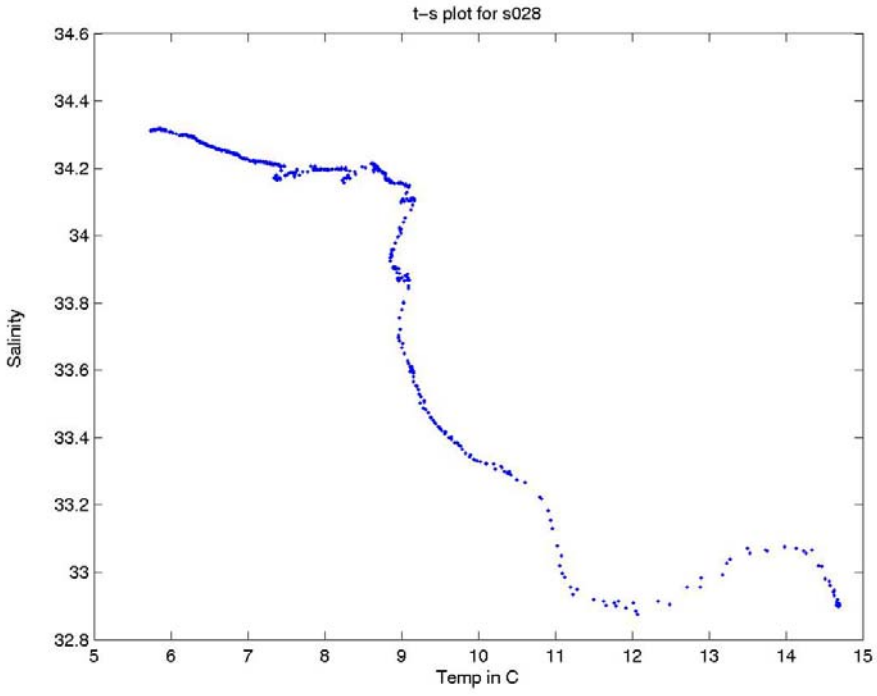
STATION S028

Station s028, much like station s022 did not show a terribly significant drop in sound speed, but the T-S plot is very interesting. At a depth of 200 meters, the salinity values rose almost to the level of the surface. This highlights the influence of the California Undercurrent in the southern stations. This station is also further up on the shelf than the other stations. This suggests that the region is experiencing the transition from the Davidson Current (predominant in the Winter-time) to the more traditional California Undercurrent conditions. (predominant in the Summer-time).



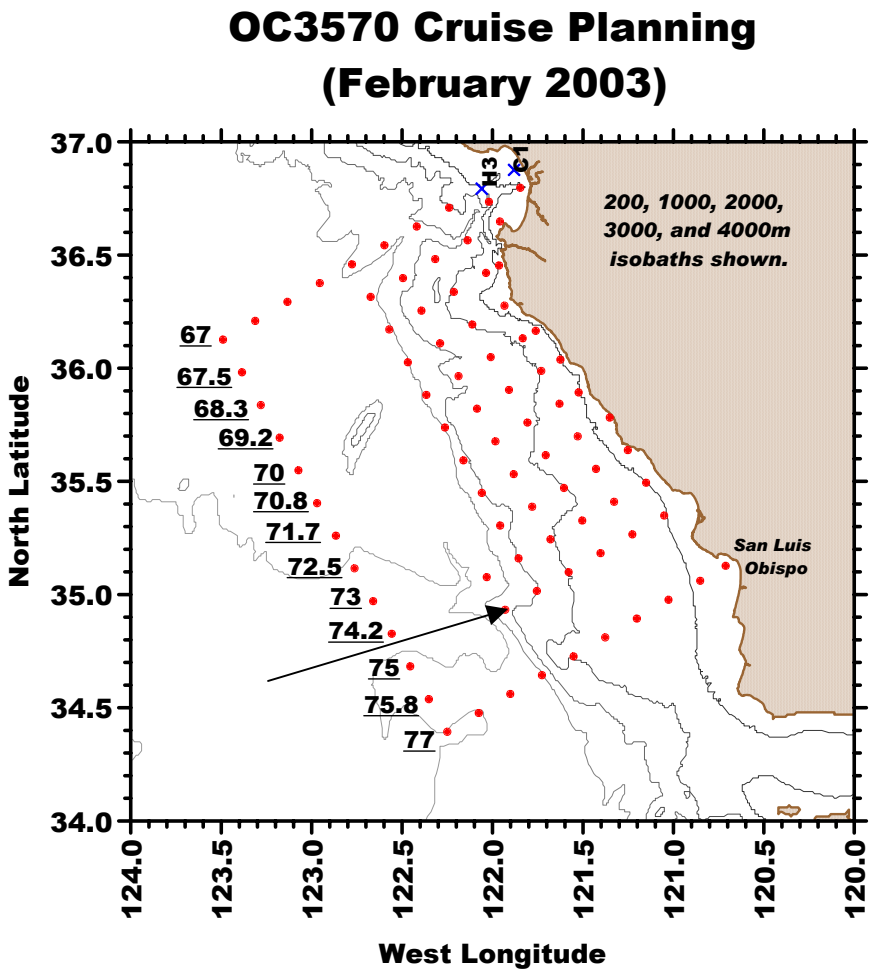
C-Z profile for station s028
(y-axis depth in meters, x-axis sound speed in m/s)



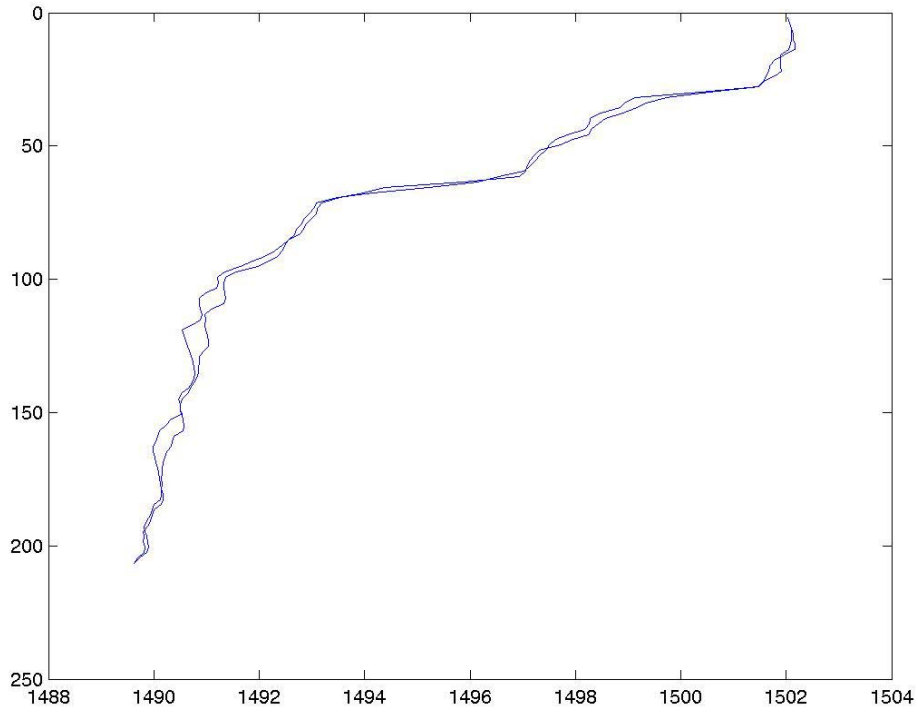


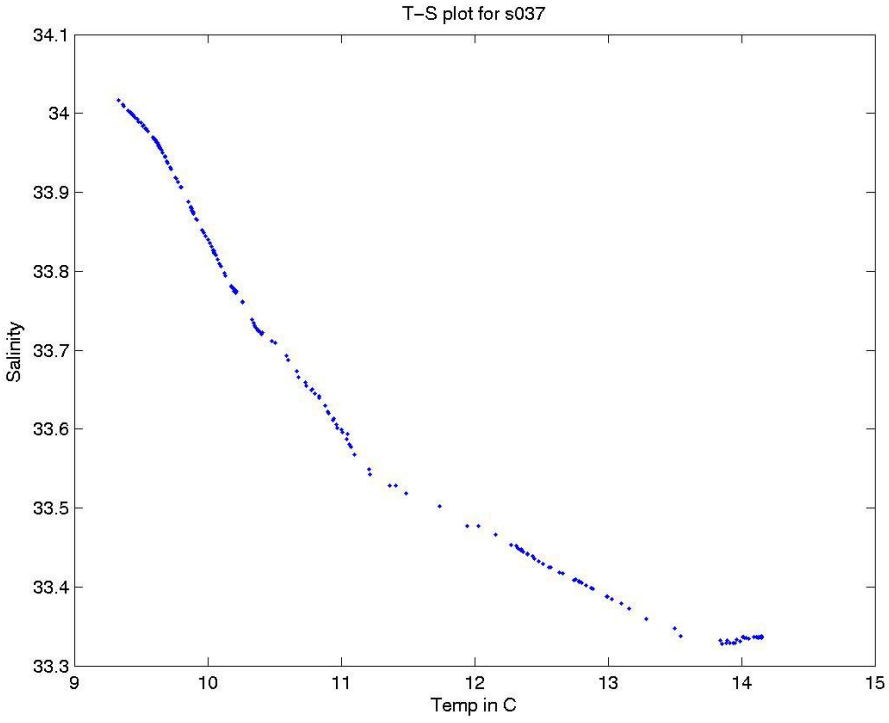
STATION S037

Station s037 was analyzed for contrast. As the California Undercurrent proceeds up the California coast, it does not necessarily follow the contour of the land. This station shows very little effect of the undercurrent. Salinity and temperature decrease with depth. This is a very normal and stable situation. No deep sound channel exists. Any acoustic rays will be directed into the bottom, where refraction can take place to propagate the ray, but much of the energy will be absorbed. Station 37 also does not have adequate depth excess to allow a true deep sound channel to form.



C-Z profile for station s037
(y-axis depth in meters, x-axis sound speed in m/s)





Conclusions

Final analysis of the data from the OC3570 cruise shows that there is definitely a signature of the California Undercurrent in the sound speed profiles of the region. The marked increase in temperature and salinity provide clues as to how his sound speed change comes about. A very distinct shallow sound channel is the result of this increase. Ships operating SONAR could utilize this shallow layer along with the deeper sound channel to achieve ranges that would normally not be possible. This, however, is only a snapshot of the dynamics between the undercurrent, the California Current, and the influence of the coastline on acoustic signatures. Since the undercurrent is strongest around the Santa Barbara area, further CTD data should be analyzed in order to get a more accurate picture of the overall direction of the current and what other influences it might have.